ISROSET- International Journal of Scientific Research in Chemical Sciences
Review Paper Volume-3, Issue-2 ISSN: 2455-3174

Study of the Waste Water Quality of Malwa Region, Bathinda, Punjab (India)

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Available online at www.isroset.org

Received: 12 Feb 2016 Revised: 24 Feb 2016 Accepted: 20 Mar 2016 Published: 05 Apr 2016

Abstract-The aim of paper is to analyze the physicochemical properties of waste water of Bathinda, Punjab (India). Now Bathinda is the well developed industrialized city in Punjab. Bathinda is the hometown of Thermal Power Plant, Ambuja Cement Factory, National Fertilizer Limited (NFL), chemicals, and dyes industries etc. These industries consume large quantity of water. Waste water discharged from these industries into natural water bodies; contaminate ground water, surface water and the soil of nearby fields. Environmental Protection Agencies (EPA) like World Health organization (WHO), Bureau of Indian Standard (BIS) set the permissible limits for the discharge of waste water into natural water bodies. The physicochemical parameters studied were color, odor, pH, temperature, Electrical Conductivity (EC), turbidity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), calcium and chlorides. Heavy metals studied were arsenic, cadmium, chromium, nickel, and lead which enter into the food chain and cause various diseases in humans and animals. From overall analysis it was observed that the waste water is highly contaminated and showed wide variations in physicochemical parameters. In the present paper an attempt has been made in physicochemical characterization of waste water to check the pollution level. The result of present research pointed out the need of some cheap remedies to treat the waste water so that it can be reused/recycled.

Keywords-*Waste Water; Physicochemical Parameters; Biological Oxygen Demand (BOD); Chemical Oxygen Demand (COD); Heavy Metals*

I. INTRODUCTION

Over the past 40 to 50 years rapid industrialization (e.g. dyes, paper, thermal power plants, pharmaceutical, paint, cement, sugar industries etc.) has resulted in the generation of increasing quantities of waste water. Discharged waste water contains high quantity of organic matter, inorganic matter and heavy metals. Wastewater is any type of water that has been adversely affected in physicochemical properties by anthropogenic activities i.e. man made activities. Waste water comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture. Petroleum hydrocarbons, chlorinated hydrocarbons, heavy metals, various acids, alkalis, dyes, detergents and other chemicals drastically change the physicochemical properties of water [1]. Bathinda is the home town of various industries e.g. Guru Nanak Dev Thermal Power Plant (GNDTPP), Milk plant (MP), National Fertilizer Limited (NFL), Ambuja Cement Factory (ACF), Paint Stores (PS), Dyes Shops (DS), refineries etc. Waste water discharged by these industries contains various organic, inorganic and heavy metal, which affects the ground water quality and soils of nearby fields and affects human's health, flora and fauna. Due to the overuse of pesticides, fertilizers, insecticides and rapid industrialization, more number of cancer cases and other diseases are now found in Bathinda district (Malwa region, Punjab) [2]. According to the survey of Health Department, Punjab, June-2005, Bathinda has 59/lakh cancer patients [3]. In 2007, epidemiological study found that the surface water of Bathinda are contaminated with arsenic, lead, cadmium, chromium, selenium and mercury primarily due to the discharge of untreated waste water from industries. Water contain high pH, total alkalinity, total hardness, turbidity, total dissolved solids (TDS), chloride, fluoride, calcium, magnesium, iron, specific conductance or conductivity and heavy metals such as arsenic, mercury and lead [4].

Today researchers are paying greater attention on the adverse environmental effects associated with the disposal of waste water particularly with the industrial waste water discharge. While discharging industrial waste water there should be proper consideration from the point of manufacturer, public because industrial waste water cause

pollution to natural water bodies making unfit for use. Waste water causes serious threat to human health and aquatic animals. The problem is more common in developing countries [5, 6, 7]. In most cases, effluents are not treated and are simply thrown into natural water bodies where they contribute to eutrophication by addition of phosphorus and nitrogen compounds to natural water bodies.

II. EXPERIMENTAL

Study area, Bathinda (Malwa region, Punjab)

Now Bathinda is the hub of industries due to the rapid industrialization and development. Guru Nanak Dev Thermal Power Plant (GNDTPP), Ambuja Cement Factory (ACF), National Fertilizer Limited (NFL), Paint Store (PS), Textile Dyes Shops (TDS), Milk Plant (MP) and other various industries are situated in Bathinda. Waste water discharged from these industries into natural water bodies contaminates ground water, surface water and the soils of the nearby fields. Various types of toxic heavy metals (As, Cd, Cr, Ni, Pb, Zn etc.) are also present in the waste water which is harmful for human health, plants and animals and recycled through food chain. Therefore, it is necessary to analyze the physicochemical properties of waste water, so that some treatment techniques can be applied to remove impurities. Following table (Table I) shows the sampling location, date of sample collection, source, and type of sample.

TABLE I. Showing the data of waste water sample collection

S.No.	Sampling location	Date of collection	Source	Type of sample
1.	National fertilizer limited (NFL), Bathinda	20/5/15	Effluent	Waste water
2.	Milk Plant (MP), Bathinda	20/5/15	Effluent	Waste water
3.	Paint Store (PS), Bathinda (wall paints, rcc pipesetc)	20/5/15	Effluent	Waste water
4	Ambuja Cement Factory (ACF), Bathinda	21/5/15	Effluent	Waste water
5	Guru Nanak Dev Thermal Power Plant (GNDTPP)	21/5/15	Effluent	Waste water
6.	Textile Dyes Shops (TDS) , Bathinda	21/5/15	Effluent	Waste water

III. MATERIAL AND METHODS

Waste water samples were collected from six different locations of Bathinda district (Malwa region, Punjab) in the month of May, 2015 shown in table 1. Borosilicate glassware, distilled water and E-Merk reagents were used throughout the experiment. Samples were collected in pre sterilized screw-capped polyethylene bottles of two liter capacity, were properly labeled and record was prepared. Waste water was analyzed in laboratory for their physico-chemical parameters. If immediate analysis is not possible store the samples at 4ºC till further analysis. Parameters analyzed by standard methods [8, 9, 10]. Various physico-chemical parameters and techniques for their analysis are given in the Table II.

TABLE II. Showing the parameters analyzed and methods used

Parameters	Methods
Odor	Physiological Sense
Temperature ◦C	Thermometer
Ph	pH metry
Turbidity(NTU)	Turbidity Meter
EC (μ mhos/cm	Conductometry
TDS (mg/l)	Standard methods by APHA, AWWA, WEF, 1998
TSS (mg/l)	Standard methods by APHA, AWWA, WEF, 1998
TS (mg/l)	Standard methods by APHA, AWWA, WEF, 1998; IS, 2003
DO(mg/l)	Iodometric method (Winkler-Azide method)
BOD(mg/l)	Iodide Azide method
COD(mg/l)	Potassium Dichromate Reflux Method
Cl (mg/l)	Silver nitrate Method
Ca (mg/l	EDTA Titration
Arsenic	ICPE (Inductively Coupled Plasma Atomic Emission Spectrometer) and ASS (Atomic Absorption Spectroscopy)
Cadmium	ICPE (Inductively Coupled Plasma Atomic Emission Spectrometer) and ASS (Atomic Absorption Spectroscopy)
Chromium	ICPE (Inductively Coupled Plasma Atomic Emission Spectrometer) and ASS (Atomic Absorption Spectroscopy)
Nickel	ICPE (Inductively Coupled Plasma Atomic Emission Spectrometer) and ASS (Atomic Absorption Spectroscopy)
Lead	ICPE (Inductively Coupled Plasma Atomic Emission Spectrometer) and ASS (Atomic Absorption Spectroscopy)

IV. RESULTS AND DISCUSSION

Waste water had color, unpleasant smell and highest turbidity. Physical parameters analyzed were pH, temperature, turbidity, conductivity, Total Dissolved

Solids (TDS), Total Suspended Solids (TSS) and Total Solids (TS). Chemical characteristics analyzed were odor, BOD, COD, chlorides, calcium, and heavy metals such as arsenic, cadmium, chromium, nickel, and lead etc. as shown in Table III and Table IV. The results were compared with desirable limit of BIS (1998) standards, IS :10500, 1991 [11].

All the waste water samples were colored from light grey to grey and blackish. It was observed that all the samples have unpleasant smell. pH is a measure of the acidity or alkalinity of water and most of the chemical reactions in aquatic environment are controlled by any change in pH value. pH is the most important factor in deciding the quality of waste water or effluent. Either highly acidic or alkaline pH would kill marine life. Heavy metals toxicity also gets enhanced at particular pH. The desirable range of pH for water is 6.5-8.5 [11]. The minimum pH observed was 5.8±0.72 from Textile Dyes Shop (TDS, Bathinda) and maximum pH value of 9.8±0.12 observed in Milk Plant (MP, Bathinda). Both the values are below and above the desirable/permissible limits. Temperature is one of the most important ecological features that control behavioral characteristics of organisms, solubility of gases and salts in water. Increase in temperature causes increase in rate of microbial activity. The major sources of thermal pollution in industries are cooling system in manufacturing or power plant. In the present investigation, the average temperature of waste water varies between minimum of 26.5±1.50 °C from Milk Plant Bathinda and Maximum of 32.3±1.53 °C for the effluents from GNDTPP, Bathinda. Turbidity is the measure of suspended matter in water. Suspended matter often includes mud, clay and slit. The excessive turbidity in water causes problems with water purification process. All the samples were highly turbid i.e. above the desirable limit of 5-10 NTU by IS (1991). National Fertilizer Limited (NFL, Bathinda) has turbidity value 80.9±2.0 NTU, Milk Plant (MP, Bathinda) 50.33±1.53 NTU, Paint Store (PS, Bathinda) 158±1.10 NTU, Ambuja Cement Factory (ACF, Bathinda) 88±1.0 NTU, Guru Nanak Dev

TABLE III. Table showing the average results of Physical Parameters of waste water in Bathinda and comparison with IS (IS :10500, 1991).

Parameter	**NFL, Bathinda**	**MP, Bathinda**	**PS, Bathinda**	**ACF, Bathinda**	**GNDTPP Bathinda**	**TDS, Bathinda**	**Desirable limit (IS standard)**
Color	Blackish	Light to medium grey	-	Blackish	Grey	Black	Colorless
pH	8.68±0.46	9.8±0.12	9.1±0.48	6.60±0.52	7.27±0.25	5.8±0.72	6.5-8.5
Tempºℂ	28.8±1.24	26.5±1.50	28.1±1.10	27.8±1.76	32.3±1.53	27.3±1.26	45ºℂ
Turbidity (NTU)	80.9±2.0	50.33±1.53	158±1.10	88±1.0	67.3±2.2	105±3.0	5-10 NTU
EC (µS/cm)	3260±1.0	1552±2.5	4805±1.0	4302±1.15	3226±2.65	3173±3.21	300 µS/cm
TDS mg/l	1998.97±2.0	1027.17±2.29	2904±4.58	3150.33±4.51	2779±3.0	3353.67±3.21	500 mg/l
TSS mg/l	131.93±2	180±2.00	240.33±2.02	150.10±1.93	120.30±2.14	497±2.68	50 mg/l
TS mg/l	2130.9±3.0	1207.17±1.20	3144.33±5.8	3300.43±4.1	2899.30±5.09	3850.67±4.51	-

TABLE IV. Results of Chemical parameters of waste water from Bathinda (Malwa region, Punjab).

Parameter	**NFL, Bathinda**	**MP, Bathinda**	**PS, Bathinda**	**ACF, Bathinda**	**GNDTPP Bathinda**	**TDS, Bathinda**	**Desirable limit (IS standard)**
Odor	Unpleasant	Unpleasant	Unpleasant	Unpleasant	Unpleasant	Unpleasant	Unobjectionable
BOD mg/l	1334	540	996	93	1025	1250	5 mg/l
COD mg/l	3025	3870	2674	265	4354	4020	10 mg/l
Concentration of Heavy metals in the waste water samples of Bathinda (Malwa region, Punjab)							
Cl mg/l	274±3.61	83.33±1.53	220±2.0	170.67±3.51	125±2.0	222.33±2.52	250 mg/l
Ca mg/l	154.0±4.0	72±2.65	167±4.0	95.33±1.53	135±4.5	89±3.6	75 mg/l
As mg/l	1.2	ND	ND	ND	1.1	0.19	0.05 mg/l
Cd mg/l	45.34	0.23	18.44	4.4	ND	0.026	0.01 mg/l
Cr mg/l	17.0	0.051	8.21	43.1	1.7	1.28	0.05 mg/l
Ni mg/l	ND	ND	23.62	ND	ND	ND	0.02 mg/l
Pb mg/l	1.6	0.035	50.55	20.5	0.16	0.12	0.05 mg/l

Thermal Power Plant (GNDTPP, Bathinda) 67.3±2.2 NTU, and Textile Dyes Shop (TDS, Bathinda) 105±3.0 NTU. All the waste water samples have turbidity values highly above the permissible limit.

Electrical conductivity (EC) is a measurement of water's capacity to carry electrical current and is directly related to the concentrations of ionized substance in the water. The permissible limit of conductivity for water is 300 µS/cm [12]. Minimum Value of EC was observed in samples of MP, Bathinda i.e. 1552±2.5 µS/cm and maximum value of EC was observed in waste water samples of PS Bathinda i.e. 4805±1.0 µS/cm. EC values of all the samples have results highly above the permissible limit because of the presence of more electrolytes in the water samples. Total Dissolved Solids (TDS) is positively correlates with electrical conductivity [13]. Permissible limit for TDS by IS:1991 is 500 mg/l. Minimum Value of TDS was observed in the sample of NFL, Bathinda i.e. 1998.97±2.0 mg/l and maximum value of TDS was observed in sample of TDS, Bathinda i.e. 3353.67±3.21 mg/l. All the waste water samples have TDS value higher than the permissible limit. Total Suspended Solids (TSS) are the materials that are not dissolved in water and are not filterable. The permissible limit for TSS is 50 mg/l [11, 12]. Minimum value of TSS observed in the samples of GNDTPP, Bathinda i.e. 120.30 mg/l±2.14 and maximum value of TSS observed in the samples of TDS, Bathinda, 497±2.68 mg/l. Total solids (TS) are the sum of TDS and TSS. It is the material suspended or dissolved in water that can physically remove either through filtration or evaporation. Minimum value of TS observed in the sample of MP, Bathinda i.e. 1207.17±1.204 mg/l and the maximum value in the sample of TDS, Bathinda i.e. 3850.67±4.51 mg/l.

Biological Oxygen Demand (BOD) is the amount of oxygen required for microbial degradation of organic matter. The desirable limit of BOD in drinking water is 5 mg/l. BOD values have been widely adopted as a measure of pollution level and Increases in BOD can be due to discharge of industrial waste water effluent, animal and crop wastes, wastewater treatment plants, food-processing plants and domestic sewage. It is one of the most common measures of organic material in waste water. Waste water samples collected from NFL, MP, PS, ACF, GNDTPP and TDS Bathinda has BOD value of 1334 mg/l, 540 mg/l, 996 mg/l, 93 mg/l, 1025 mg/l, 1250 mg/l and 1250 mg/l respectively. According to UN Department of Technical Cooperation for Development the maximum permitted BOD content is < 100 to 300 mg/L. [1]. Chemical Oxygen Demand (COD) is a measure of the oxygen equivalent of the portion of the organic matter in the sample which is susceptible to oxidation by a strong chemical oxidant. *COD* is the most common measures of pollutant organic material in waste water. Samples collected from NFL, MP, PS, ACF, GNDTPP and TDS Bathinda has COD values 3025 mg/l, 3870 mg/l, 2674 mg/l, 265 mg/l, 4354 mg/l, and 4020 mg/l respectively.

Chloride content occurs in all natural waters in widely varying concentrations and the excessive chloride in potable water is not particularly harmful. Chloride anions are related to palatability and potentially high corrosiveness [14]. Desired limit for chlorine in water is 250 mg/l for drinking water [12]. Minimum chloride content was found in the sample of MP, Bathinda i.e. 83.33±1.53 mg/l and the maximum chloride content was observed in the sample of NFL, Bathinda i.e. 274±3.61 mg/l. Desired limit for calcium in drinking water is 75 mg/l [12]. Minimum calcium value of 72±2.65 mg/l (within the permissible limit) observed in the samples of MP, Bathinda and maximum calcium value of 154.0±4.0 mg/l observed in the sample of NFL, Bathinda.

Arsenic is the toxic heavy metal and according to the ISI standard (1991) [12], the desirable limit for arsenic in drinking water is 0.05 mg/l. Arsenic is present in the sample of NFL, Bathinda (1.2 mg/l), GNDTPP, Bathinda (1.1 mg/l) and TDS (0.19 mg/l) i.e. the concentration of arsenic is above the permissible limit. Arsenic was absent in the sample of ACF, PS, and TDS, Bathinda. According to the WHO and BIS standard permissible limit for cadmium in water is 0.01 mg/l. Cadmium is present in the sample of NFL, (105.0 mg/l), PS (18.44 mg/l), ACF, (4.4 mg/l), TDS, (0.026 mg/l), MP, (0.23 mg/l). Cadmium is absent in the sample of and GNDTPP, Bathinda. According to WHO and BIS standards prescribed limit for chromium is 0.05 mg/l. Chromium is present in the sample of NFL, (17.0 mg/l), MP, (0.51 mg/l), PS (8.21 mg/l), ACF, (43.1mg/l), GNDTPP, (1.7 mg/l), and TDS, (1.28 mg/l). Nickel was only present in the sample of PS (23.62 mg/l) and absent in all the samples. According to the ISI (1991)[12] the desirable limit for Ni in the drinking water is 0.02 mg/l. Nickel is present in the sample of NFL (1.6 mg/l), ACF (20.5 mg/l), GNDTPP (0.16 mg/l) and TDS (0.12 mg/l). The desirable concentration for lead is 0.05 mg/l [12]. Lead is present in the sample of NFL (1.6 mg/l), MP (0.035mg/l), PS (50.55 mg/l), ACF (20.5 mg/l), GNDTPP (0.16 mg/l) and TDS (0.12 mg/l).

V. CONCLUSION

The results of physicochemical properties show that the waste water is highly contaminated, contains inorganic, organic materials and heavy metals in high concentration. All the samples have unpleasant smell and light grey to grey and black in color. All the samples have pH values of below and above the permissible limit. Values of turbidity, EC, TDS, TSS, TS, BOD, COD, Ca, and chloride are very high. The waste water contains the high concentration of heavy metals also i.e. above the permissible limit. In most cases, effluents are not treated and are simply thrown into natural water bodies where they cause eutrophication by adding phosphorus and nitrogen compounds to natural water bodies and which contaminate the surface water, ground water and the soils of the fields. Due to this contamination people of Bathinda (Malwa region, Punjab) are highly prone for the immediate health diseases e.g. cancer, fluorosis and gastro-intestinal irritation, anemia, leucopenia, abdominal pain, vomiting, diarrhea, muscular pain, weakness with flushing of the skin followed by numbness, tingling of the extremities, muscular cramping, and the appearance of an erythematous rash etc. There is immediate need of some cheap waste water treatment technology for the removal of contaminants from waste water so that this water can be reused.

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